TYPE OF REPORT: Quarterly

TIME PERIOD: July-September, 1993

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OVERVIEW

During the reporting period, we continued our development and supporting research for the MODIS BRDF-Albedo and Land Cover/Land Cover Change products. This work included modeling, validation, and empirical studies involving data analysis.

TASK PROGRESS

BRDF/Albedo Product

Model Development

During this period, we completed the first phase of development of the hybrid model that predicts the BRDF of a natural vegetation cover composed of individual plant crowns using radiative transfer and geometric optics. This model utilizes conditional path length statistics and assumes that scattering and attenuation are constant within a plant crown and thus negative exponential functions of path lengths. A manuscript describing the model was submitted for publication in IEEE Transactions on Geoscience and Remote Sensing. (See publication list below.)

We also continued development of the Monte Carlo surface BRDF model and the stochastic BRDF model. The former models the BRDF of a heterogeneous mixed pixel with topographic relief, and the latter models the influence of the atmosphere on the BRDF of a surface composed of three-dimensional envelopes of scattering media. Both of these efforts are directed toward the understanding of the spatial aggregation problem of land surface covers as it applies to BRDF.

We further completed the development of the four-stream model, which provides an analytical solution to the radiative transfer equation for a coupled atmosphere-nonlambertian surface system using a four-stream

solution for multiple scattering. The surface BRDF is described empirically. A manuscript describing the model and its validation by comparison with very accurate iterative solutions to the radiative transfer equation was submitted to Applied Optics. (See publication list below.) This model was then broadened by coupling it to a leaf canopy instead of an empirical non-Lambertian BRDF. This version is similar in concept to the previously-developed two-stream coupled analytical invertible model, but is more accurate because of the four-stream solution for multiple scattering.

Model Validation

In collaboration with USAF Phillips Laboratory, we continued the construction of a distributed-parameter BRDF database for the Stanislaus National Forest for the purpose of albedo simulation. The database characterizes the geometric-optical characteristics of the vegetation cover of each 30-m pixel and calculates the albedo of the scene as a whole, using the terrain-dependent version of the mutual shadowing BRDF model. Early indications are that the solar spectrum albedo for the entire diverse scene is quite conservative, varying only by +-10% or so with different sun angles. This suggests that albedo generalizes well over large regions, which is an important conclusion for climatic modelers as well as for the preparation of our BRDF/Albedo product.

Algorithm Development

We also began the development of the specific algorithm to be used to recover BRDF and albedo from MODIS and MISR data. Our primary efforts were devoted to the drafting of the Algorithm Technical Basis Document, and to beginning the coding of the invertible models required.

Land Cover/Land-Cover Change Products

Land Cover

The first part of our study of the effects of resolution cell size on the distribution of land cover units was completed during this reporting period, and a manscript was submitted for publication. (See Publications section.) This research showed that estimates of the proportions of land cover types vary as a function of spatial resolution, with large changes occurring as aggregation becomes coarser and coarser. The changes are influenced by the initial coverage of each land cover class as related to that of other classes, and to the spatial pattern of occurrence (e.g., patch size

and shape) of the class. The target area for the study is the Plumas National Forest in the Sierra Nevada of California. Work continued on the second part of this study, which focuses on measures of spatial pattern and structure of land cover units at fine resolution and their effects on coarse-resolution proportion estimation.

We also began work on the use of neural net classifiers for the land cover product. This involved a literature survey and development of a liason with Dr. Suchi Gopal, of the BU Geography Department, who has worked in this field and maintains ties to the BU Institute of Cognitive and Neural Science.

Land-Cover Change

During this period, we continued development of the change-vector technique for identifying and quantifying land-cover change processes. We further refined incorporation of land surface temperature, as inferred from AVHRR channels 4 and 5 using the split-window algorithm. The target region continued to be the west African Sahelian-Sudanian zone as imaged in a multitemporal AVHRR 1-km dataset kindly provided by J. Malingreau from the EC Joint Research Center at Ispra, Italy. We completed the revision of a manuscript describing the use of reflective, thermal, and spatial information in change process characterization. (See Publications section.)

Algorithm Development

A considerable effort during this period was devoted to the drafting of the Land Cover/Land-Cover Change Product ATBD. The document was circulated to all members of the Land Team in late July, and comments were received for incorporation in the final document as submitted during the fall Team Meeting.

In development of the Land Cover ATBD, Team Member Steve Running provided an alternative scenario for preparation of the Land Cover Parameter. In an independent study, he and Tom Loveland of EDC explored a simple 6-category classification that provided land covers suited for use in biogeochemical modeling as needed for the Photosynthesis-Net Primary Productivity Product. This classification used simple thresholding techniques on the EDC conterminous U. S. composited AVHRR dataset. Although the accuracy of this categorization has not been tested, the approach remains an alternative to neural nets that is very attractive due to its simplicity. With additional information from thermal channels, with

topographic and broad climatic data, and with MISR directional data and/or the BRDF product, and without the "benefit" of compositing, the simple thresholding approach or an analogous technique may prove sufficiently accurate to obviate the need for more powerful, but more highly trained, classifiers such as those involving neural nets.

Our development of the Land Cover algorithm is being slowed by lack of suitable datasets for development. The Plumas National Forest dataset is our first target, but as yet the MODIS SDST has not been able to provide us with the 250- and 500-m imagery convolved from the TM data we supplied. Also lacking is the registered AVHRR data from the EDC 1-km dataset. However, we know that the SDST is working on the problem and will be satisfying our needs shortly.

ANTICIPATED ACTIVITIES DURING THE NEXT QUARTER

BRDF/Albedo Product

During the next quarter, we will focus on algorithm development in preparation for our first software delivery on or about January 1, 1994. Since there are different algorithms for each of the five BRDF cases, this effort involves the further development and testing of several models. These include the development and testing of a simple, empirical BRDF model for mixed-pixel cases and its inversion; development of inversion codes for the Li-Strahler geometric-optical model; and model and inversion code development for the terrain-facet-driven BRDF models.

Land Cover/Land-Cover Change Product

We will continue the studies of land cover proportion estimation at coarse spatial resolutions, and finalize our results with a second manuscript to be ready near the first of the year. As soon as the database, supplied by SDST, is ready, we will begin trials comparing the neural net classifier to the Running-Loveland thresholding method. For the Land-Cover Change Parameter, we will concentrate on further development and processing of the Asian LAC dataset being provided by Malingreau at the JRC in Ispra.

PROBLEMS/CORRECTIVE ACTIONS

During this quarter, we did not encounter any significant problems requiring corrective actions beyond the every day problems that occur in research and algorithm development.

OTHER ACTIVITIES

1. Prof. Eric Lambin, who is carrying out the development of the Land-Cover Change parameter and algorithm, left in late August for a four-month leave of absence to be spent in J. Malingreau's laboratory at the EEC Joint Research Center in Ispra. He will continue studies of land-cover change there using a 1-km AVHRR dataset from southeast Asia, which he will bring back to BU for further work in FY94.

2. The Principal Investigator attended the NSF-sponsored meeting of scientists involved in the the Long-Term Ecological Research (LTER) program. The meeting was held in Estes Park, Colorado, September 18-22. At the meeting, several MODLAND PIs conducted a workshop session on the use of LTER sites as MODIS test sites for validation of Running's Photosynthesis-Net Primary Productivity Product, as well as other products. A specific proposal to NASA/NSF is under development by Running for the validation activity.

3. The Principal Investigator attended the MODIS Science Team Meeting at GSFC, September 29-October 1.

4. Dr. Shunlin Liang departed on September 1 for the University of Maryland, where he has a postdoctoral appointment funded by GSFC as the AVHRR Pathfinder Land Scientist.

PUBLICATIONS

The status of pending publications supported all or in part by this contract and its predecessor is shown below.

Submitted

The following manuscripts were submitted for publication during this reporting period:

Li, X., A. H. Strahler, and C. E. Woodcock, 1994, A hybrid geometric optical-radiative transfer approach for modeling albedo and dicretional reflectance of discontinuous canopies, IEEE Trans. Geosci. and Remote Sens., submitted.

Moody, A., and C. E. Woodcock, 1994, Scale-dependent errors in the estimation of land-cover proportions--Implications for global land-cover datasets, Remote Sens. Environ., submitted.

Previously Submitted

The following manuscripts were previously submitted and are in the review process:

Liang, S. and A. H. Strahler, 1994, Retrieval of surface BRDF from multiangle remotely sensed data, to Remote Sens. Environ., submitted.

Liang, S., and A. H. Strahler, 1994, A four-stream solution for atmospheric radiance transfer over a non-Lambertian surface, Applied Optics, submitted.

Revised and Accepted

The following manuscripts were accepted for publication with revision, were revised, and resubmitted during this reporting period:

Barnsley, M. J., A. H. Strahler, K. P. Morris, and J.-P. Muller, 1993, Sampling the surface bidirectional reflectance distribution function (BRDF): Evaluation of current and future satellite sensors, Remote Sensing Reviews, in press.

Moody, A. and A. H. Strahler, 1993, Characteristics of composited AVHRR data and problems in their classification, Int. J. Remote Sens., in press.

Running, S., C. Justice, D. Hall, A. Huete, Y. Kaufmann, J-P. Muller, A. Strahler, V. Vanderbilt, Z-M. Wan, 1994, Terrestrial remote sensing science and algorithms planned for EOS/MODIS, Remote Sens. Environ., in press.

Lambin, E. F. and A. H. Strahler, 1994, Change-vector analysis: A tool to detect and categorize land-cover change processes using high temporal-resolution satellite data, Remote Sens. Environ., in press.

Lambin, E. F. and A. H. Strahler, 1994, Indicators of Land-Cover Change for Change-Vector Analysis in Multitemporal Space at Course Spatial Scales, Int. J. Remote Sens., in press.

In Press

The following manuscripts were in press during this reporting period:

Schaaf, C. B. and A. H. Strahler, 1993, Solar zenith angle effects on forest canopy hemispherical reflectances calculated with a geometric-optical bidirectional reflectance model, IEEE Trans. Geosci. and Remote Sens., vol. 31, no. 4, in press.

Liang, S. and A. H. Strahler, 1993, An analytic BRDF model of canopy radiative transfer and its inversion, IEEE Trans. Geosci. and Remote Sens., vol. 31, no. 5, in press.

Abuelgasim, A. A. and A. H. Strahler, 1993, Modeling bidirectional radiance measurements collected by the Advanced Solid-State Array Spectroradiometer (ASAS) over Oregon Transect conifer forests, Remote Sens. of Environ., in press.

Published

Liang, S. and A. H. Strahler, Calculation of the angular radiance distribution for a coupled system of atmosphere and canopy media using an improved Gauss-Seidel algorithm, IEEE Trans. Geosci. and Remote Sens., vol. 31, pp. 491-502.

Schaaf, C. L. B., and A. H. Strahler, 1993, Modeling the bidirectional reflectance and spectral albedo of a conifer forest, Proceedings, 25th International Symposium on Remote Sensing and Global Environmental Change, April 2-8, 1993, Graz, Austria, vol. 2, pp. 594-601.